Pak. J. Bot., 39(5): 1533-1538, 2007.

PAKISTAN RICE GENETIC RESOURCES–II: DISTRIBUTION PATTERN OF GRAIN MORPHOLOGICAL DIVERSITY

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Abstract

Rice grain quality characters pertaining to morphology were evaluated for diversity within Pakistan local rice germplasm; 475 accessions collected from 3-rice cultivation zones and other parts of the country. The altitudinal distribution patterns were carried out for some grain quality traits.

A wide variation was found in grain size, shape and weight. The variation observed for these traits seemed to bear some correlation for its distribution with respect to altitude of collection site. Pakistan rice cultivars were dominated by long grain type while the short grains were absent, according to the measured length. However, based on grain length/width ratio, 1 % short grain types were present in regions of higher altitude. The long grain types were not recorded from altitudes above 1500 m.

Introduction

Rice is the 2nd most important food crop in Pakistan in respect of local consumption as well as exports. It is grown on approximately more than 2.5 million hectares, with a total production of 5.0 million tones (Anon., 2005). Grain quality is a very wide subject encompassing diverse characters that are directly or indirectly related to exhibit one quality type. Variation in any one character or character-combination results in the changed quality of rice grain (Siddiqui *et al*., 2007). Webb *et al*., (1979, 1985) noticed a particular trend of grain cooking quality characters related to grain shape. Due to wide spread distribution in different agro-climatic conditions and diversified selection for a wide range of uses of rice grain; a great diversity exists for its size and shape (Satoh *et al.*, 1990a, b). Therefore the rice grain quality characteristics diversity pertaining to grain morphology and color was evaluated for Pakistan rice genetic resources (Siddiqui *et al*., 2007).

Genetic diversity is a prerequisite for increasing yields and for stabilizing production in the face of disease epidemic and fluctuating environmental condition (Sano, 2000). Grain morphology is among the first to be a visible character for selection and quality marking. This character is also considered while collecting germplasm for conservation. Therefore keeping in view the importance of grain shape and the attributed characters combination for cooking quality, investigation on seed morphological characters in relation to its occurrence were carried out for Pakistan local rice cultivars. The data for grain morphological variation was speculated with the objective to determine the pattern of morphological variation in the rice collected regions or any relationship of studied variation to its altitudinal distribution.

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Materials and Methods

Materials for this study (mature rice seeds-475 accessions) were obtained from the National Genebank of MAFF (Ministry of Agriculture, Food and Fisheries) Genebank, Tsukuba, Japan. Complete data (Passport information) was obtained from the National Genebank at the Plant Genetic Resources Program (PGRP), National Agricultural Research Centre (NARC), Islamabad, Pakistan (Anon., 1995).

Measurements were done for length, width and breadth (thickness) of un-hulled grain as reported by Satoh *et al*., (1990a, b), with 5 replications. Length to width ratio was also calculated based on average of respective values of seed morphology. Pakistan rice cultivars were classified into Long-, Medium- and Short grain types according to Adair *et al*., (1973) using length and length/width ratio. Distribution of recorded characters was correlated to its altitude of collection site, which is described herein.

Results

The Pakistan rice genetic resources showed a great diversity for all the measured grain morphological characters (Siddiqui *et al*., 2007). The variation for grain length ranged from 10.66 ~ 6.0 mm, grain width from 3.7 ~ 1.6 mm, breadth from 2.36 ~ 1.14 mm, length to width ratio varied from 5.24 ~ 2.04 and grain weight from 3.02 ~ 0.66 g.

Based on length to width ratio, long and medium grain types were found distributed in all locations along the altitude range. However, the short grain types were only recorded from above 800 m range (Table 1).

The altitudinal distribution of grain types is given in Table 1. As can be seen here, 72.5% of the long grain types were distributed below 400 m altitude, 26.4% between 600 ~ 1500 m and only 1% above 1500 m altitude. Whereas in case of medium grain type, only 12.9% were distributed in low altitude range of 400 m or below, 57.3% in altitude between 600 ~ 1500 m and 29.8% above 1500 m altitude. In case of short grain type no record was found in low altitude and all were collected from high altitude range (Table 1).

The pericarp color was either white or red. Both color type of pericarp showed mixed occurrence in all the locations. However, the frequency of red pericarp rice was more in low altitude, while that of white pericarp grains had higher frequency in high altitude (Fig. 1).

Discussion

The Pakistan rice genetic resources showed a great diversity for all the measured seed morphological characters (Siddiqui *et al*., 2007). Sano (2000) has stated that phenotypic diversity increases during domestication as a general trend in crop plants. However, variation for pericarp color was the minimum in Pakistan rice cultivars being either white or red (Fig. 1). The color type of pericarp showed mixed occurrence, however, the frequency of red pericarp rice was more in low altitude areas and it gradually decreased with the increase in altitude. It was interesting to note that in low altitude area particularly Punjab, here 85% area is cultivated with Basmati rice, which is white grain, but local cultivars are mostly of red color in this region. The white pericarp grains had higher frequency in high altitude areas, the frequency of which decreased with the decrease in altitude range (Fig. 1). These results indicate that there is a shift in the genetic diversity towards monoculture of basmati varieties. Therefore the threatened rice genetic resources must be conserved before they are replaced by improved varieties.

Table 1. Grain size distribution of Pakistan rice cultivars in altitude range based on

grain length/width ratio*.

Altitude m	Long grain type	Medium grain type	Short grain type
70 ~ 100	11	02 -	-
101 ~ 200	54 (73%)	06 (13%)	-
201 ~ 300	71	19	-
301 ~ 400	04	03	-
601 ~ 700	07	20	-
701 ~ 800	07	09	-
801 ~ 900	10	11	1
901 ~ 1000	05	14	-
1001 ~ 1100	02 (26%)	20 (57%)	-
1101 ~ 1200	02	19	-
1201 ~ 1300	04	05	-
1301 ~ 1400	10	10	-
1401 ~ 1500	04	25	1
1501 ~ 1600	01	08	-
1601 ~ 1700	-	03	-
1701 ~ 1800	- (%)	15 (30%)	-
1801 ~ 1900	01	25	1
1901 ~ 2000	-	14	-
2001 ~ 2100	-	04	-
Total	193	232	3
%	(45.09)	(54.21)	(0.70)

*Long grain type = L/W ratio more than 3.0, Medium grain type = L/W ratio between 2.1 and 3.0 and Short grain type = L/W ratio less than 2.1.
(Note: 47 accessions with no altitude data were excluded)

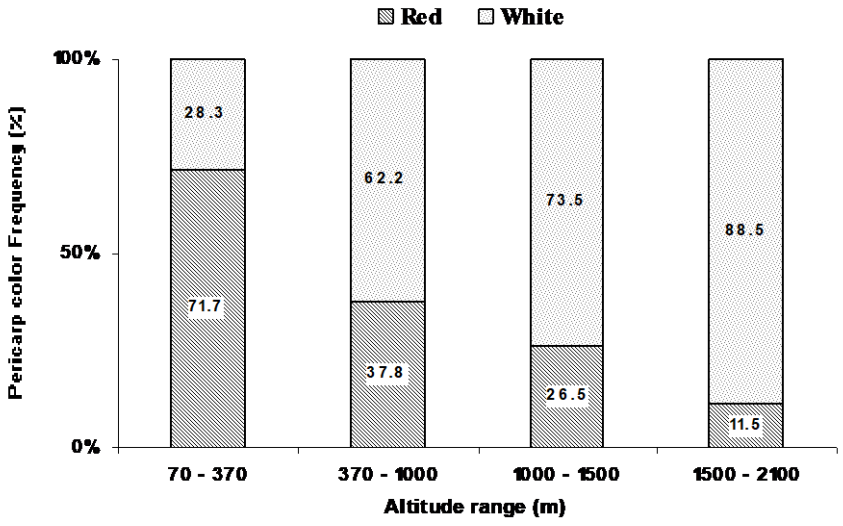

Fig. 1. Distribution pattern of pericarp color variation in Pakistan rice germplasm in relation to altitudinal occurrence.

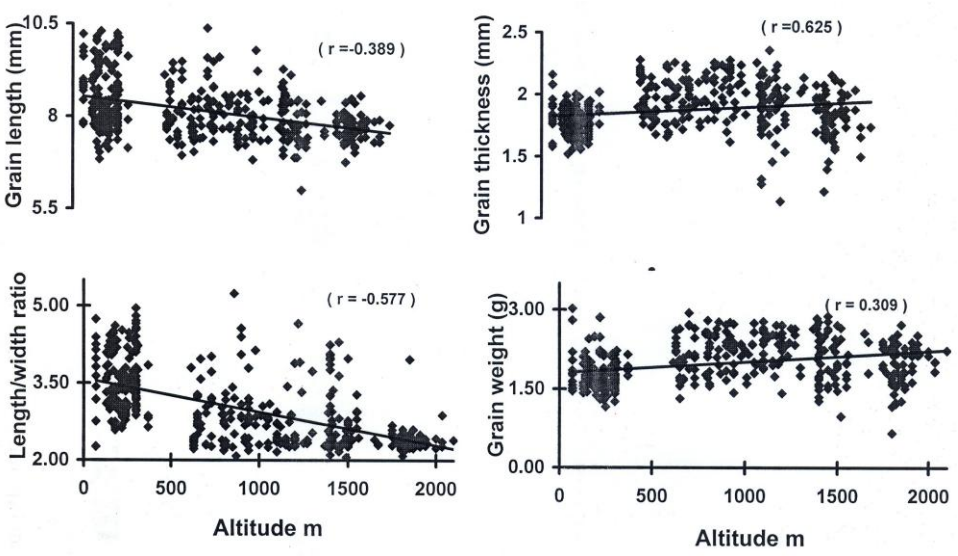

Fig. 2. Altitudinal distribution of rice grain morphological characteristics for Pakistan rice germplasm (with correlation in parenthesis).

Similar pattern of distribution was observed for grain shape with reference to altitude of collection site. Plants sampled from 70 to 400 m altitude mainly long grain types (73%) were dominant, compared to medium type (13%) in the same altitude range. This clearly demonstrates the attitude towards selection for grain types. Whereas, above 1500 m mainly medium grain types (30%) were present and only 1% of long grain type were recorded. These results again support the distinct distribution of grain type in relation to altitude of collection. While, both types were recorded in the altitude range of 600 to 1500 m (26% long grain type v/s 57% medium grain type), though dominated by medium grain type by two folds. It was interesting to note that in elevation between 400 to 600 m, no rice was either recorded or grown (Table 1). Nagamine *et al*., (1992) has reported similar distribution pattern for Chinese rice germplasm in the Yunnan province for grain shape.

The existence of great diversity in the seed morphology i.e., length, length to width ratio, thickness and grain weight (Fig. 2) and grain type distribution along the altitude range (Table 1) indicates the presence of other related agronomic, physiological, cooking, nutritional traits or cultural aspects for their selection and adoption. The people in the low altitude areas prefer to eat long grain type particularly aromatic variety Basmati, while people in the higher elevations prefer to eat roundish shaped rice. However, the true short grain type is not preferred as only 4 cultivars fall in this category of the total 475 accessions. Katsuta & Okuno (1992) also showed that the local varieties in northern Pakistan are typically classified into two groups, based on the shape of grain. According to them, varieties of the round shaped Japonica type are adapted to higher locations, whereas, varieties of the slender shaped Indica type are distributed in the location below 1000m. Though their study was on selected cultivars and limited to northern Pakistan, their findings are in accordance with the results of present study to some extent.

It maybe interesting to note that compared to longest grain from Punjab 10.24 mm with length/width ratio 4.7, the grains as long as 9.3 mm, having the length/width ratio of 4.1 were recorded from high altitude of 1400 m. It shows that there exist long grain cultivars adapted to high altitude range, however, preference is for growing roundish rice grain (having lower length to width ratio). In location their distribution is given in Table 1, where it can be seen that long and medium grain types were found in all locations, whereas, the short grain type was only recorded from NWFP/NA. It was also noted that in the altitude range of 400-600 m no rice was collected or grown, so it is imperative to know whether no rice is grown in these localities or germplasm was not collected, which must be collected before it is lost.

The altitudinal distributions of grain length, grain width, grain length to width ratio and grain weight is given in Fig. 2. It was noticed that grain length decreased with the increase in altitude ($r = -0.389$), while the grain width increased with the increase in altitude ($r = +0.625$), resulting into a decrease in length to width ratio ($r = -0.577$) with the increase in altitude. Though the grain length decreased in high altitude the increase in width compensated for grain volume to accumulate the grain weight ($r = +0.309$), as it showed an increasing trend with increase in altitude (Fig. 2), though other factors are also involved in the grain filling. These results suggest that Pakistan rice cultivars possess a distinct correlation in terms of altitudinal distribution for grain morphology. A positive correlation of grain width and seed weight with altitude increase and a negative correlation of grain length and length to width ratio was found with increasing altitude (Fig.2). Considering the change in altitude as a difference in habitat and environment, it can be assumed that Pakistan rice cultivars show a wide variation between and within locations.

It may be concluded that the Pakistan rice genetic resources comprise of great diversity for grain morphological characteristics. However, the variation for hull and pericarp color was minimum. The prevailing diversity for grain type (shape and size) and pericarp color has distinct correlation to its geographical distribution in terms of altitude.

The preference of people in southern Pakistan and in plains is for long grain type rice, whereas those of people in Northern mountain region prefer for roundish grain i.e., medium grain type. Long grain type cultivars suitable for higher altitudes are present and grown by few farmers in mountain region.

Acknowledgements

The research was conducted at the Laboratory of Plant Genetic Resources, Institute of Genetic Resources, Faculty of Agriculture, Kyushu University, Fukuoka, Japan; and funded by Ministry of Education, Sports, Culture, Science and Technology, Government of Japan which is acknowledged.

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(Received for publication 13 October 2005)